(54) [Title of the Invention]

BIRFIELD CONSTANT VELOCITY JOINT AND MANUFACTURING METHOD THEREOF

(57) [Abstract]

[Problem] To provide a birfield constant velocity joint and a manufacturing method thereof, which suppresses temperature rise at the time of an operation by reducing a friction coefficient, to prevent flaking of a ball.

[Resolution Means] In a birfield constant velocity joint, molybdenum disulfide powder and an organic molybdenum compound generated by reacting molybdenum disulfide in a high temperature area are added as a lubricant agent to grease that is filled in a constant velocity joint assembled of an outer race, an inner race, a retainer and a ball, by forming fine recesses on surfaces of ball rolling grooves in the outer race and the inner race through the use of shot blast, and furthermore, forming manganese phosphate films on the outer face and the inner race.

[Claims]

[Claim 1]

A birfield constant velocity joint comprising four components of an outer race and an inner race having ball rolling grooves, a retainer for holding a ball at a constant

velocity surface position, and a ball, characterized in that surfaces of the ball rolling grooves of the outer race and the inner race have fine recesses, and furthermore, entire surfaces of any one or both components of the outer race and the inner race have manganese phosphate films, and at least molybdenum disulfide powder and an organic molybdenum compound generated by reacting molybdenum disulfide in a high temperature area are added as a lubrication additive agent to grease that is filled in the constant velocity joint assembled of four components of the outer race, the inner race, the retainer and the ball.

[Claim 2]

A manufacturing method of a birfield constant velocity joint comprising four components of an outer race and an inner race having ball rolling grooves, a retainer for holding a ball at a constant velocity surface position, and a ball, characterized in that cold plastic forming, and then, heat treatment are applied to the outer race and the inner race, and shot blast processing is applied to at least the ball rolling grooves of the outer race and the inner race after the cold plastic forming and/or the heat treatment, and then, manganese phosphate processing is applied to any one or both components of the outer race and the inner race, and grease in which at least molybdenum disulfide powder and an organic molybdenum compound generated by reacting molybdenum

disulfide in a high temperature area are added as a lubrication additive agent is filled in the constant velocity joint assembled of four components of the outer race, the inner race, the retainer and the ball.

[Detailed Description of the Invention]

[0001]

[Technical Field to which the Invention Belongs]

The present invention relates to a birfield constant velocity joint that is used for a front wheel etc. of a front-wheel drive automobile, and more particularly, relates to a ball endurance improving technique of the birfield constant velocity joint.

[0002]

[Prior Art]

Fig.1 shows a cross-sectional view of a birfield constant velocity joint, and Figs.2 - 4 show an outer race, an inner race, and a retainer, which configure the constant velocity joint, respectively. Input torque, which is given from a shaft 5, is transmitted to an inner race 2 through spline fitting, and then, transmitted to an inner race ball rolling groove 2a, a ball 3, an outer race ball rolling groove 1a, and an outer race 1. In addition, a retainer 4 is spherical surface-fitted into an outer race inner spherical surface 1b and an inner race outer spherical surface 2b, and a ball 3 is always positioned

on a two equal part dividing surface of an angle (joint angle) A formed by two axes, and thereby, a constant velocity performance of the joint is assured.

[0003]

In the constant velocity joint like this, at the time of the joint angle A = 0 degree, the outer race 1 and the inner race 2 are equivalent to being merely spline-fitted through the ball 3, and therefore, sliding does not occur in the constant velocity joint, but at the time of the joint angle A > 0 degree, the ball 3, the outer race ball rolling groove 1a and the inner race ball rolling groove 2a generate rolling-sliding mixed sliding with an angular amplitude A, and the retainer 4, the outer race inner spherical surface 1b and the inner race outer spherical surface 2b generate sliding with an angular amplitude A/2. In addition, along with this, in order for the retainer 4 to position the rolling ball 3, sliding occurs also between them.

[0004]

As to a sliding condition at this time, in case of a constant velocity joint that is used for a front-wheel drive automobile, sliding velocity does not become larger so much, since frequency of vibration is approximately 30Hz at the highest, but there is such a case that a load goes up to the vicinity of 3GPa at a place where the load is the largest. In the situation like this, a high load is always applied

repeatedly to the ball, and therefore, metal fatigue occurs on a ball surface, and that portion is eventually peeled off in the shape of flake (flaking), and this decides operating life of the constant velocity joint. Especially, under the above-described severe sliding condition, temperature of an outer circumference of the outer race exceeds 100°C easily, and grease to be filed deteriorates depending on temperature, and operating life of the ball is shortened more.

[0005]

In order to solve the above problem and improve operating life of a ball, i.e., operating life of a constant velocity joint, it is designed to reduce a surface pressure of a sliding place as much as possible from a design side, and it is designed to reduce a friction coefficient at the above-mentioned each sliding place as much as possible from a lubrication side.

[0006]

In this regard, however, in case of the design intending to reduce a sliding surface pressure, a constant velocity joint becomes large in size generally, and it has a limitation from a current trend of weight saving and miniaturization of automobile parts. In addition, advancement of grease including improvement of heat resistance is brilliant from a lubrication side, but it is still hard to say that it is sufficient.

[0007]

On the one hand, as a devisal from the lubrication side, a measure has been tried such as applying manganese phosphate processing to a component surface of a constant velocity joint, and coating a lubrication resin paint including a solid-state lubricant agent such as molybdenum disulfide in addition to the manganese phosphate processing, as shown in JP-B-1-55688. In this regard, however, the manganese phosphate processing has an operation for forming a surface that is advantageous to sliding while preventing a metal-metal contact of a sliding surface in the initial stage of sliding (initial acquainting property), but it eventually disappears by friction, and therefore, its effect is not permanent. In addition, as to a method of further carrying out the lubrication resin coating after the manganese phosphate processing, a friction coefficient reduction effect of a sliding surface is larger as compared with a case using only the manganese phosphate processing, and it is more effective, but is of high cost, and especially in a high surface pressure sliding condition, it eventually disappears by friction in the same manner as in the case using only the manganese phosphate processing.

[0008]

Therefore, a current situation is that a low cost constant velocity joint having sufficient operating life has not yet been obtained, under a severe sliding condition that is unavoidable for responding to a current trend of weight saving

and miniaturization of automobile parts.

[0009]

[Problem that the Invention is to Solve]

Then, an object of the invention is to solve the above-mentioned problem in the prior art, and concretely speaking, an object is to provide a longer operating life constant velocity joint and a manufacturing method thereof, by permanently reducing a friction coefficient between respective components, even in a severe sliding condition of a high surface pressure, to restrain temperature rise at the time of operation, and accordingly prevent flaking of a ball.

[0010]

[Means for Solving the Problem]

The inventors of the invention devoted themselves to carry out researches in order to solve the above-mentioned problem, and as a result, they newly found that the above problem is solved by a constant velocity joint to which the following three measures are applied simultaneously;

a) mechanical surface treatment is applied to a ball rolling groove of a constant velocity joint component performed forming process, and thereby, a fine recess is formed in the surface,

b) manganese phosphate processing is further applied to the component, and

c) a specific lubrication additive agent is applied to grease

that is filled in an assembled constant velocity joint

[0011]

That is, a birfield constant velocity joint of the invention comprises four components of an outer race and an inner race having ball rolling grooves, a retainer for holding a ball at a constant velocity surface position, and a ball, and is characterized in that surfaces of the ball rolling grooves of the outer race and the inner race have fine recesses, and furthermore, entire surfaces of any one or both components of the outer race and the inner race have manganese phosphate films, and at least molybdenum disulfide powder and an organic molybdenum compound generated by reacting molybdenum disulfide in a high temperature area are added as a lubrication additive agent to grease that is filled in the constant velocity joint assembled of four components of the outer race, the inner race, the retainer and the ball.

[0012]

Furthermore, a manufacturing method of a birfield constant velocity joint of the invention is, in a birfield constant velocity joint comprising four components of an outer race and an inner race having ball rolling grooves, a retainer for holding a ball at a constant velocity surface position, and a ball, characterized in that cold plastic forming, and then, heat treatment are applied to the outer race and the inner race, and shot blast processing is applied to at least the ball

rolling grooves of the outer race and the inner race after the cold plastic forming and/or the heat treatment, and then, manganese phosphate processing is applied to any one or both components of the outer race and the inner race, and grease in which at least molybdenum disulfide powder and an organic molybdenum compound generated by reacting molybdenum disulfide in a high temperature area are added as a lubrication additive agent is filled in the constant velocity joint assembled of four components of the outer race, the inner race, the retainer and the ball.

[0013]

For the outer race used in the birfield constant velocity joint of the invention, it is possible to use structural steel such as JIS S50C - S60C, and for the inner race, it is possible to use structural alloy steel such as JIS SCR420 or SCM420. As to respective component shaped in the shape of an outer race and an inner race by a cold plastic forming process, it is necessary to form fine recesses on the surfaces by applying shot blast processing to at least their ball rolling grooves. This processing also has a purpose for removing a lubricant agent attached at the time of plastic forming, in order not to exert a harmful influence to subsequent heat treatment, but its main purpose is absolutely to form a fine recess on a surface, and therefore, surface finishing such as polishing should not be applied to at least their ball rolling grooves after the

shot blast.

[0014]

Next, heat treatment such as quenching - annealing is applied to the outer race and the inner race in order to give material strength to them. It is desirable that hardness of a material surface at this time is HRC55 - 65. In addition, an oxide film is formed on a material surface by this heat treatment, but it is desirable that the oxide film is removed in order to carry out subsequent manganese phosphate processing stably. Normally, a mechanical method such as shot blast, or a chemical method such as acid washing is applied for removing an oxide film, but in the invention, the former mechanical method is desirable by the above-mentioned reason.

[0015]

In the above-mentioned process, two processes at maximum of shot blast are carried out, but there is no need to apply shot blast processing to both of after plastic forming and after heat treatment, since there is not necessarily a problem if a fine recess exists on a component surface, in a stage prior to subsequent manganese phosphate processing being applied. In this regard, however, since a surface is hardened after heat treatment, it is hard to obtain a recess forming effect due to shot blast, and therefore, it is desirable that it is carried out after plastic forming, and it is more desirable that it is also carried out after heat treatment in consideration of

a processing property of manganese phosphate. In terms of results, as to the recess on the ball rolling groove formed by the above process, it is desirable that an average diameter of the recess is Φ30 - 80μm, and a depth is 10 - 30μm. Therefore, a method of shot blast and a blast material are not limited in particular, but normally, as the blast material, a hard steel ball (Φ10 - 30μm, hardness HRC 40 - 50) etc. are used, and it is carried out by use of a super core knockout type shot blast device etc.

[0016]

Next, manganese phosphate processing is applied to the outer race and/or the inner race whose surface a fine recess is formed on. A method of the manganese phosphate processing is not limited in particular, and it is all right if a commercially available manganese phosphate processing medical agent is used. That is, it is all right if oil spot on a surface is washed and removed by use of an alkaline degreasing agent, and thereafter, heating to 90°C or more is applied to phosphoric acid aqueous solution including divalent manganese ions and nitrate ions etc. as oxidant, and it is immersed in it for approximately 10 minutes. In addition, when it is processed to be immersed in a surface adjustor in which manganese phosphate fine particles are dispersed in aqueous solution in the colloidal shape, prior to the manganese phosphate processing, manganese phosphate processing is carried out more

stably, and therefore, it is desirable.

[0017]

The manganese phosphate processing goes with etching of an iron steel in its reaction process, and therefore, a manganese phosphate film is formed on the surface while forming irregularity in some degree, but it is possible to have a manganese phosphate film existed into a deeper portion, by forming a fine recess on a component surface in advance through the use of a mechanical method as in the invention.

[0018]

It is most desirable to apply the manganese phosphate processing to both of the outer race and the inner race, but it is all right even if it is applied to one of them according to circumstances. In this regard, however, in each case, it should not be applied to a retainer that is described next.

[0019]

Next, as for a retainer that is used in the constant velocity joint, higher processing accuracy is normally required as compared with the outer race and the inner race. Therefore, it is desirable to use low-carbon steel that is easily processed, as a material of the retainer, but a high surface pressure is applied in use for the purpose of positioning a ball, and therefore, structural ally steel, to which chromium and molybdenum are added, should be used in consideration of a subsequent carburization quenching

property. The retainer like this is finally finished to a high accuracy by cutting processing and surface polishing processing, and thereafter, carburization quenching - annealing is carried out, but it is desirable that hardness of a material surface at this time is HRC 60 - 65.

[0020]

As for a ball that is used in the constant velocity joint of the invention, high-carbon steel, e.g., bearing steel should be used for the purpose of securing at least fatigue strength, and it is desirable that surface hardness after quenching - annealing is HRC 60 - 65. Furthermore, high sphericity is required for the ball, and therefore, a surface shape should not be changed by e.g., the above-mentioned mechanical surface processing etc., and chemical processing like manganese phosphate processing should not be carried out either.

[0021]

In the birfield constant velocity joint of the invention having the above-mentioned configuration, a surface, which is appropriate to sliding, is finished in a state of a low friction coefficient, while a manganese phosphate film holds well grease and a lubrication additive agent added to the grease, in the same way as a normal manganese phosphate processing steel surface, in the initial acquainting stage. When a use continues in this state, the manganese phosphate film

disappears by friction. However, in the invention, the manganese phosphate film exists even in a recess formed in advance by shot blast processing, and therefore, a number of recesses, in which the manganese phosphate film exists, remain even if the manganese phosphate film in the acquainting process disappears, and it is possible to permanently continue a retention effect of a lubricant agent.

[0022]

Figs.5 - 7 are pattern diagrams of prior art. As shown in Fig.5, a manganese phosphate film is formed on a steel surface. This manganese phosphate film prevent a metal - metal contact, and retains a lubricant agent well, but as shown in Fig.6, itself is worn away and becomes a flat surface. When a use continues in this state, the manganese phosphate film itself finally disappears by friction as shown in Fig.7.

[0023]

Figs.8 - 9 are pattern diagrams of the invention technique. As seen in Fig.8, a manganese phosphate film is also formed in a recess formed by shot blast. Also in the invention, it finally becomes a flat surface as shown in Fig.9, but the manganese phosphate film remains in the recess formed by shot blast, and therefore, retention capability for a lubricant agent continues.

[0024]

In this regard, however, there exists a portion from which

a steel surface is exposed partially, in a stage that the initial acquainting process is completed (see, Fig.9), and therefore, there also exists a portion in which a metal - metal contact due to sliding may occur. In order to secure a sliding property of this portion, molybdenum disulfide particles and an organic molybdenum compound generated by reacting molybdenum disulfide in a high temperature area must be added as a lubrication additive agent to grease that is used in the constant velocity joint assembled of the invention.

[0025]

As to the molybdenum disulfide particles, it is desirable that its average particle diameter is 2 - 10μm, and addition concentration to entire grease is 1 - 10 weight%. In addition, as the organic molybdenum compound, it is possible to use Mo-DTC (molybdenum-dithiocarbamate) and/or Mo-DTP (molybdenum-dithiophosphate) etc., and it is desirable that an average particle diameter in this case is 2 - 10μm, and its addition concentration is 1 - 10 weight%.

[0026]

The molybdenum disulfide particle itself is absorbed and attached to an exposed iron surface, to develop a low friction coefficient, but it is decomposed to become molybdenum trioxide in a portion where temperature becomes high locally, and its effect is lost. On the one hand, the organic molybdenum compound is self-decomposed in a portion where temperature

becomes high locally, and molybdenum disulfide is newly generated, to repair a portion where a lubrication effect is lost. Therefore, these tow lubrication additive agents must exist simultaneously.

[0027]

[Embodiments]

Hereinafter, embodiments of the invention are explained more concretely, together with comparative examples, but the invention is not restricted by these embodiments.

[0028]

Combinations of each component and a grease additive agent, which configure constant velocity joints used as the embodiments and the comparative examples, and their evaluation results are shown in Table 1.

[0029]

[Table 1]

	Outer race			Inner race			Retainer	Grease additive agent	Evaluation result	
	FS	HS	PM	FS	HS	PM	PM		Tem.°C	FP
Embodiment 1	Y	Y	Y	Y	Y	Y	N	MoS_2, Mo-DTC	83	10
Embodiment 2	Y	N	N	Y	Y	Y	N	MoS_2, Mo-DTC	95	30
Embodiment 3	Y	Y	Y	Y	N	N	N	MoS_2, Mo-DTC	85	28
Comparative example 1	Y	Y	Y	Y	Y	Y	N	Only MO-DTC	112	15
Comparative example 2	Y	Y	Y	Y	Y	Y	Y	MoS_2, Mo-DTC	126	6
Comparative example 3	N	N	Y	N	N	Y	N	MoS_2, Mo-DTC	100	21
Comparative example 4	Y	Y	N	Y	Y	N	N	MoS_2, Mo-DTC	104	19

FS existence (Y): there is shot blast processing after cold forge processing.

FS nonexistence (N): there is no shot blasting after cold forge processing.

HS existence (Y): there is shot blast processing after heat

treatment.

HS nonexistence (N): there is no shot blast processing after heat treatment.

PM existence (Y): there is manganese phosphate processing.

PM nonexistence (N): there is no manganese phosphate processing.

MoS_2: molybdenum disulfide particles.

Mo-DTC: molybdenum-dithiocarbamate

Temperature of evaluation result: temperature of an outer circumference of an outer race in operation of a constant velocity joint.

FP of evaluation result: flaking point (30 points as full mark ... no flaking).

[0030]

As the outer race and the inner race, a JIS S55C material and a JIS SCM 420 material are used respectively, and they were formed in actual shapes by cold forge processing, and thereafter, high frequency quenching - annealing was applied to the outer race and carburization quenching - annealing was applied to the inner race. As to both of the components, surface hardness at this timing was HRC 60. In addition, the shot blast after forge processing and after heat treatment was carried out by using a hard steel ball (average particle diameter Φ0.20 micron, hardness HRC 45) as a blast material, and using a super core knockout type blast device.

[0031]

As the retainer, a JIS SCM415 material is used, and it was formed in an actual shape by cutting processing and surface polishing processing, and thereafter, carburization quenching - annealing was carried out. Surface hardness at this timing was HRC 62.

[0032]

The manganese phosphate processing was carried out in a manner that an object to be processed was immersed in 2% aqueous solution of strong alkaline degreasing agent Fine Cleaner 4360, which is heated to 60°C and made by Nippon Parkerizing Co., Ltd., for 5 minutes, and thereafter, it was washed by water to clean the surface, and thereafter, it was immersed in normal

temperature mixed solution of surface adjustor Preparen VMA 3g/l made by Nippon Parkerizing Co., Ltd., and Preparen VMB 3g/l made by the same, for 1 minute, and was immediately immersed in 14% aqueous solution of a manganese phosphate processing agent Parfos M1A, which is heated to 95°C and made by Nippon Parkerizing Co., Ltd., for 10 minutes, and thereafter, washed by water sufficiently. At this time, in order to stably carry out manganese phosphate processing, steel wool was previously put into the manganese phosphate processing agent with a ratio of 10g/L, after it is heated to 95°C, to entrain iron ions therein.

[0033]

As the steel ball, a JIS SUJ2 material, to which quenching - annealing is applied, was used. A retainer and 6 pieces of steel balls are assembled with an outer race and an inner race to which the above-mentioned each processing was applied in the combination shown in Table 1, to accomplish a constant velocity joint for evaluation.

[0034]

Grease, which is filled in the constant velocity joint, is formed by using mineral grease to which a urea puffing agent is used as a base, and molybdenum disulfide particles of an average particle diameter 5μm are added with a ratio of 3 weight%, and molybdenum-dithiocarbamate of an average particle diameter 5μm is added with a ratio of 3 weight%, to

it according to need.

[0035]

The constant velocity joint for evaluation manufactured by the above was operated for 160 hours with rotation number 1400rpm, by setting a joint angle to 8 degree and applying a load of torque 25kgm. The evaluation was carried out by average temperature on an outer surface of an outer race in operation and visual determination of a ball flaking state where it was removed after termination of the operation. The flaking determination is carried out by 5 step evaluations as below, and by its total score (full mark: 30 points) since there is 6 pieces of balls.

[0036]

5 points: no flaking, 4 points: flaking is seen slightly, 3 points: flaking is seen, 2 points: heavy flaking is seen, 1 point: heavier flaking is seen.

As obvious from the results in Table 1, it is understood in the constant velocity joint of the invention that temperature rise in operation is suppressed, and ball flaking occurrence frequency is extremely low. In contrast to this, in case of methods of the comparative examples, i.e., no necessary lubrication additive agent being included in grease (comparative example 1) and no shot blast processing and no manganese phosphate processing being applied (comparative examples 3 and 4), temperature rise is large and flaking is

also heavy. Especially, when manganese phosphate processing is applied to all components of an outer race, an inner race and a retainer (comparative example 2), heavy flaking is generated.

[0037]

[Advantage of the Invention]

In a constant velocity joint of the invention, it is possible to considerably improve flaking life even in an extremely harsh operating condition, and therefore, it is possible to provide large design freedom of constant velocity joints, and it is possible to realize weight saving and miniaturization of constant velocity joints, in accordance with current trend of automobile weight waving.

[Brief Description of the Drawings]

[Fig.1] a vertical cross-sectional view of a birfield constant velocity joint.

[Fig.2] a view showing an outer face.

[Fig.3] a view showing an inner race.

[Fig.4] a view showing a retainer.

[Fig.5] a cross-sectional conceptual diagram of a steel surface to which manganese phosphate processing by prior art is applied.

[Fig.6] a conceptual diagram of an acquainting process of the steel surface to which manganese phosphate processing by prior art is applied.

[Fig.7] a view showing that a flat surface, which is advantageous to sliding, is formed by prior art, but a manganese phosphate film disappears by friction.

[Fig.8] a cross-sectional conceptual diagram of the steel surface to which manganese phosphate processing by the invention is applied.

[Fig.9] a view showing that a flat surface is formed by the invention, and moreover, a manganese phosphate film remains in a recess.

[Description of Reference Numerals and Signs]

1: outer race, 1a: outer race ball rolling groove, 1b: outer race inner spherical surface, 2: inner race, 2a: inner race ball rolling groove, 2b: inner race outer spherical surface, 3: ball, 4: retainer, 5: shaft, 6: boots.